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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

August 5, 1997

Mr. William F. Caton
Secretary
Federal Communications Commission
1919 M. St., NW, Room 222
Washington, D.C. 20554

EX PARTE OR LATE FILED

RE: Ex Parte Presentation – Proxy Cost Models
CC Docket No. 97-160

Dear Mr. Caton,

AT&T and MCI are pleased to submit Release 4.0 of the Hatfield Model for the Commission and the Federal-State Joint Board's consideration in CC Docket Nos. 96-45 and 97-160. The programming logic and inputs in this release of the model differ only very slightly from the preliminary version of Release 4.0 that was submitted on July 14, 1997. These differences are noted in the model's included documentation.

The most significant enhancements offered with this filing are: (1) the inclusion of individually executed expense modules for the largest carrier in each state (typically an RBOC), as well as an executed expense module for each state that incorporates data from all of the smaller carriers in that state; (2) a copy of the Hatfield Inputs Portfolio that provides the evidence that the model's sponsors have amassed in support of the national default values for the over 1200 user-adjustable inputs to the model; and (3) a CD-ROM that contains all of the above, plus the model's other documentation in electronic format.

Two copies of this Notice are being submitted to the Secretary of the FCC in accordance with Section 1.1206(a)(1) of the Commission's rules. Copies of the CD-ROM are being filed with the Secretary and with ITS.

Sincerely,

Richard N. Clarke

Richard N. Clarke

Attachments and CD-ROM

cc: Federal and State Service List

No. of Copies rec'd 0+2
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Contents

* The executed expense module on the CD-ROM for Ohio Bell was not run using its correct Distance File, thus it improperly indicates no signaling costs for STPs. Users should re-run the model to create an accurate expense module for Ohio Bell. The paper output provided here does display the correct signaling costs for Ohio Bell.

Hatfield Model

Release 4.0

Model Description

Hatfield Associates, Inc.

737 29th Street, Suite 200
Boulder, Colorado 80303

August 1, 1997

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I. INTRODUCTION

A. OVERVIEW

The Hatfield Model has been developed by Hatfield Associates, Inc. (HAI), of Boulder, Colorado, at the request of AT&T and MCI for the purpose of estimating the forward-looking economic costs of 1) unbundled network elements (UNEs), based on Total Element Long Run Incremental Cost (TELRIC) principles;[1] 2) basic local telephone service, as defined by the Federal-State Joint Board on Universal Service ("Joint Board") for universal service funding purposes; and 3) carrier access to, and interconnection with, the local exchange network. All three sets of costs are calculated using a consistent set of assumptions, procedures and input data.

The Hatfield Model calculates the costs of the following UNEs:

- Network Interface Device (NID)
- Loop Distribution
- Loop Concentrator/Multiplexer
- Loop Feeder
- End Office Switching
- Common Transport
- Dedicated Transport
- Direct Transport
- Tandem Switching
- Signaling Links
- Signal Transfer Point (STP)
- Service Control Point (SCP)
- Operator Systems
- Public Telephones

The Hatfield Model uses the definition of "universal service" recommended by the Joint Board.[2] The recommendation states that the following functional components be considered as universal service:

- single-line, single-party access to the first point of switching in a local

[1] TELRIC is the term used by the Federal Communications Commission to refer to the total service long run incremental cost (TSLRIC) of unbundled network elements.

[2] Federal-State Joint Board on Universal Service, CC Docket No. 96-45, Recommended Decision, November 8, 1996, ("Recommended Decision") Paragraph 45-53, 65-70.

exchange network;
- usage within a local exchange area, including access to interexchange service;
- touch tone capability;
- a white pages directory listing; and
- access to 911 services, operator services, directory assistance, and telecommunications relay service for the hearing-impaired.

Excluded from this definition of universal service are many other local exchange company (LEC) services, such as toll calling, custom calling and CLASS℠ features, and private line services. The existence of such services is taken into account in developing the cost estimates for UNEs -- to the extent that the joint provision of UNEs and other services impacts the costs of UNEs. Model users also may adjust the degree to which several specific UNEs are included in calculating universal service support requirements.

Finally, the model estimates the per-minute economic cost of providing local network interconnection and access. These are estimated for connection points at end office and tandem switches.

The model constructs a "bottoms up" estimate of the pertinent costs based upon detailed data describing demand quantities, network component prices, operational costs, network operations costs, and other factors affecting the costs of providing local service. The model's demand data, such as customer locations, line demand, and traffic volumes, serves as a key driver. From these data, the model engineers and costs a local exchange network with sufficient capacity to meet total demand, and to maintain a high level of service quality. The model's inputs also include the prices of various network components, with their associated installation and placement costs, along with various capital cost parameters. These data are used to populate detailed input tables describing, for example, the cost per foot of various sizes of copper and fiber cable, cost per line of switching, cost of debt, and depreciation lives for each specific network component.

Using these data, the model calculates required network investments by detailed plant category. It then determines the capital carrying cost of these investments. Operations expenses are then added to compute the total monthly cost of universal service, carrier access and interconnection, and various unbundled network elements, stated on both a total cost and an appropriate per-unit basis. Costs are then displayed on a study area, density zone, wire center, or Census Block Group (CBG) basis.[3]

This document describes the structure and operation of the Hatfield Model,

[3] A CBG is a unit defined by the U. S. Bureau of the Census, and nominally comprises between 400 and 600 households.

Release 4.0 ("HM 4.0"), including a discussion of various inputs to the model. Subsection B of this section describes the evolution of the Hatfield Model. Section II summarizes changes made to the model between HM 3.1 and this version. Section III provides a general overview of the local network being modeled and the model's organization. Section IV describes each module and its operation in detail. Section V summarizes the document.

Appendix A documents the data input development process to obtain demographic and geological information, residence and business line counts, wire center mappings, wire center distance calculations, and percent of the land area of each Census Block Group that is unoccupied. Appendix B identifies the user inputs to the model and their default values.

B. EVOLUTION OF THE HATFIELD MODEL

The Hatfield Model was originally developed to produce estimates of the Total Service Long Run Incremental Cost (TSLRIC) of basic local telephone service as part of an examination of the cost of universal service. This original model was a "greenfield" model in that it assumed all network facilities would be built without consideration given to the location of existing wire centers or transmission routes. When the original Benchmark Cost Model (BCM1)[4] became available, HAI revised the original Hatfield Model to incorporate certain loop investment data produced by BCM1. As a result, the Hatfield Model adopted BCM1's "scorched node" methodology. The outputs from the BCM1 loop modeling process, substantially modified by including the cost of items not included in BCM1, were then combined with extensive wire center and interoffice and expense calculations enhanced from the earlier Hatfield Model to develop a complete set of TSLRIC estimates.

An expanded version of earlier Hatfield Models, referred to as the Hatfield Model, Version 2.2, Release 1, was developed early in 1996 to estimate the costs of unbundled network elements. It was submitted to the Federal Communications Commission (FCC) in CC Docket No. 96-98 on May 16 and 30, 1996, accompanied by descriptive documentation.[5] On July 3, 1996, that model was also placed into the record of CC Docket No. 96-45 to assist the Commission in determining the

[4] The Benchmark Cost Model is a model of basic local telephone service developed by MCI, NYNEX, Sprint, and U S WEST.

[5] See Appendix E of the *Comments* of AT&T in CC Docket No. 96-98, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, and Appendix D of AT&T's *Reply Comments*. In the same proceeding, MCI submitted results based on an earlier "greenfield" version of the Model as Attachment 1 to its *Comments*.

economic costs of universal service.[6]

Further enhancements to this model were contained in the Hatfield Model, Version 2.2, Release 2 ("HM 2.2.2"). This version of the model estimated the efficient, forward-looking economic cost of both unbundled network elements and basic local telephone service. HM 2.2.2 derived certain of its inputs and methods from the BCM-PLUS model, a derivative of BCM1 that was developed and copyrighted by MCI Telecommunications Corporation.[7]

On August 8, 1996, the FCC released its First Report and Order in CC Docket No. 96-98, Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, and CC Docket No. 95-185, Interconnection between Local Exchange Carriers and Commercial Mobile Radio Service Providers ("Interconnection Order"). The Interconnection Order provided a comprehensive set of criteria for the arrangements through which the incumbent Local Exchange Carriers (ILECs) would offer unbundled network elements to competitive local exchange carriers (CLECs). The criteria included a definition of a cost-based methodology that should be used in setting the price of unbundled network elements. The methodology was termed the Total Element Long Run Incremental Cost, or TELRIC. The methodology of the Hatfield Model is fully consistent with the TELRIC principles set forth in the Order.

AT&T and MCI used HM 2.2.2 as the basis for their recommended prices for unbundled network elements in a large number of state jurisdictions during the latter part of 1996. As a result, the model has already been examined thoroughly in arbitration proceedings by the ILECs, state commission staffs, and other parties. Its results have also been adopted in whole or in part in several of these proceedings.

On November 8, 1996, the Joint Board issued its Recommended Decision in CC Docket No. 96-45.[8] In addition to defining Universal Service, the Board also addressed the issue of determining the level of support required for universal service. In doing so, it found that:

> . . . a properly crafted proxy model can be used to calculate the forward-looking economic costs for specific geographic areas,

[6] See FCC Public Notice, DA-96-1078, Released July 3, 1996 and DA 1094, Released July 10, 1996 ("Cost Model Public Notice").

[7] On July 3, 1996, Sprint Corporation and U S WEST presented version 2 of the BCM (called BCM2) to the FCC. NYNEX and MCI are not sponsors of BCM2. A careful review by HAI indicated that all of BCM2's relevant enhancements over BCM1 were already present in the HM 2.2.2. Furthermore, the HM 2.2.2 has important attributes and capabilities that are not available in the BCM2.

[8] Op. cit., Recommended Decision.

> and be used as the cost input in determining the level of support a carrier may need to serve a high cost area. The Joint Board therefore recommends that the Commission continue to work with the state commissions to develop an adequate proxy model that can be used to determine the cost of providing supported services in a particular geographic area . . ..[9]

An in-depth review of these issues was also provided in the Competitive Pricing Division Staff Analysis of "The Use of Computer Models for Estimating Forward-Looking Economic Costs."[10] Further suggestions for the improvement of proxy models were advanced at workshops conducted by the Joint Board on January 14 and 15, 1997. Although the Board has so far declined to recommend any particular proxy model, it has provided an extensive review of the existing models, and established a number of criteria such models should meet.[11]

On February 7, 1997, AT&T and MCI submitted to the Joint Board a preliminary version of a new release of the Hatfield Model, Release 3.0, with accompanying documentation. The submission included data and results for five states: California, Colorado, New Jersey, Texas, and Washington.[12] HM 3.0 addressed the concerns raised by the Joint Board in its consideration of proxy cost models and the FCC in its consideration of modeling the forward looking economic cost of interconnection. It was responsive to the principles established and concerns raised about existing models, in the Interconnection Order, the Joint Board Recommendation and in Staff Papers and Workshops.

Later the same month, on February 28, AT&T and MCI submitted Hatfield Model Release 3.1 (HM 3.1). It incorporated certain minor modifications to HM 3.0; further, it contained data for 49 states plus the District of Columbia.

In April, 1997, the state members of the Universal Service Joint Board issued several reports about proxy cost modeling. Although these reports provided useful analyses of desired features within the models, they came to no clear final conclusion on the choice of a model.

On May 7, 1997, the FCC released its Order implementing the mandate for

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[9] Ibid., paragraph 268.

[10] Released January, 9, 1997.

[11] Ibid., paragraphs 273-277 and Appendix F.

[12] Results from Release 3.0 were submitted in three state proceedings: Kansas, Virginia, and Washington, that took place later in February.

universal service contained in the Telecommunications Act of 1996. In the Order, it declined, on the basis of its current record, to endorse a model and indicated it would issue a Further Notice of Proposed Rulemaking (FNPRM) detailing what it believed to be the appropriate requirements and guidelines that such a cost methodology should incorporate.[13] This Order and the FNPRM provide a substantial amount of information about what the Commission believes are the appropriate properties a proxy cost methodology should incorporate. The Commission indicated its intention to select a model for determining universal service support for nonrural carriers by the end of 1997.

HM 4.0 is responsive to the Commission's requirements as presented in the Order, and most of the requirements outlined in the FNPRM on cost modeling. Furthermore, several enhancements have been placed in HM 4.0 to reduce the additional model development effort that will be required to meet the Commission's requirements in regard to refinement of methods to locate customers.[14] HM 4.0 provides a number of enhancements to HM 3.1, including, but not limited to, the several outlined in an *ex parte* submission to the Commission on June 5, 1997. In addition, HM 4.0 contains an improved and more accurate version of the demographic database.

II. SUMMARY OF CHANGES BETWEEN HM 3.1 AND HM 4.0

A number of significant changes have been made to HM 3.1 in developing HM 4.0.[15] These changes are reflected in the discussion of how the new version operates, presented in Section III. They can be summarized as follows:

Input Data and User Interface

- Includes improved counts of lines served by certain small LECs based on data from the USF NOI (Universal Service Fund Notice of Inquiry Data Request from 1994); USTA (United States Telephone Association); and RUS (Rural Utilities Service);

[13] This FNPRM was released on July 18, 1997.

[14] Because this effort is both extremely complex and sensitive to the results of the Commission's current efforts to seek more detailed data from the ILECs as to the quantity and character of customer demand, it will be incorporated in a subsequent revision of the Hatfield Model.

[15] The changes listed below are those that are incremental to the modifications to HM 3.1 that were effected to the model as outlined in AT&T's ex parte submission of April 29, 1997.

- incorporates a more accurate list of wireline wire centers and associates CBGs with these wire centers more accurately;

- allows the user to input the fraction of reported private line and special access circuits that are DS-0, DS-1 and DS-3 facilities, to accommodate such data when available;

- contains more user-adjustable inputs, including effects of soil types on placement difficulty, cable placement activity factors, and others;

- allows the count of residence and business lines to be normalized to the counts reported by the ILEC for each wire center, to the extent that information is provided or available.

<u>Distribution Module and Feeder Module</u>

- Changes the default impact of difficult soil conditions by increasing the cost of placement instead of increasing assumed route distances;

- explicitly accounts for various activities associated with the placement of outside plant, and provides user-adjustable inputs for the amount and cost of such activities;

- increases the cost of cable placement linearly as a function of bedrock depth rather than as a step function increase when the bedrock depth is less than the user threshold.

<u>Distribution Module</u>

- Allows the user to set the percentage of customers located in population clusters on a CBG-by-CBG basis, or, alternatively, to use an overall percentage as in version 3.1.

- replaces the treatment of long loops using coarse-gauge cable and load coils to one using T1 technology to reach within 18,000 feet of each customer. This ensures that all customers can receive digital services at an ISDN Basic Rate Interface or faster digital data rate;

- provides a more sophisticated calculation of the investment in the Serving Area Interface (SAI) as a function of the number of lines served from the SAI;

- computes drop investment per location using detailed input demographic information for each CBG, and otherwise refines the calculation of drop costs;

- computes and displays the achieved distribution fill level at the SAI instead of at the branch cable;

- assumes the use of 26-gauge cable rather than 24-gauge cable for cable sizes of 400 pairs and larger, consistent with loop resistance design and the limitation of copper loop lengths to 18,000 feet.

Switching and Interoffice Module

- Provides the user additional flexibility in specifying the switching cost by allowing both the "slope" term in the switching cost function and the constant term to be varied.

Expense Module

- Allows the user to control via "toggles" the line categories (primary residence lines, secondary residence lines, single-line businesses, multi-line businesses, public) that are included in supported universal service;

- separates the economic lives and salvage values of the capital plant categories;

- includes general support and miscellaneous expenses in the calculation of carrier-to-carrier expenses;

- displays the versions of Distribution, Feeder, and Switching/Interoffice Modules used to compute investment;

- includes a more sophisticated universal service output sheet that displays significantly more detailed support results;

- provides sharing of manhole costs with other low-voltage users;

- explicitly accounts for the difference in business and residence dial equipment minutes (DEMs) in determining usage costs for Universal Service Fund calculations.

Preliminary Version of HM 4.0 to Current Version

Several minor changes have also occurred in the model, its data and interface between the preliminary filing of HM 4.0 on July 14, 1997 and the current August 1, 1997 release of HM 4.0. These include:

- cleanup of lines data for some of the telcos;
- adjusted default values for buried drop placement costs and structure sharing;

- elimination of several incompatibilities in the operating interface;
- correction of the treatment of access costs for business lines in the Density Zone expense module USF sheet;
- cleanup of numerous calculations in the Wire Center expense module to ensure greater consistency with calculation methods in the Density Zone expense module.

III. STRUCTURE OF THE HATFIELD MODEL

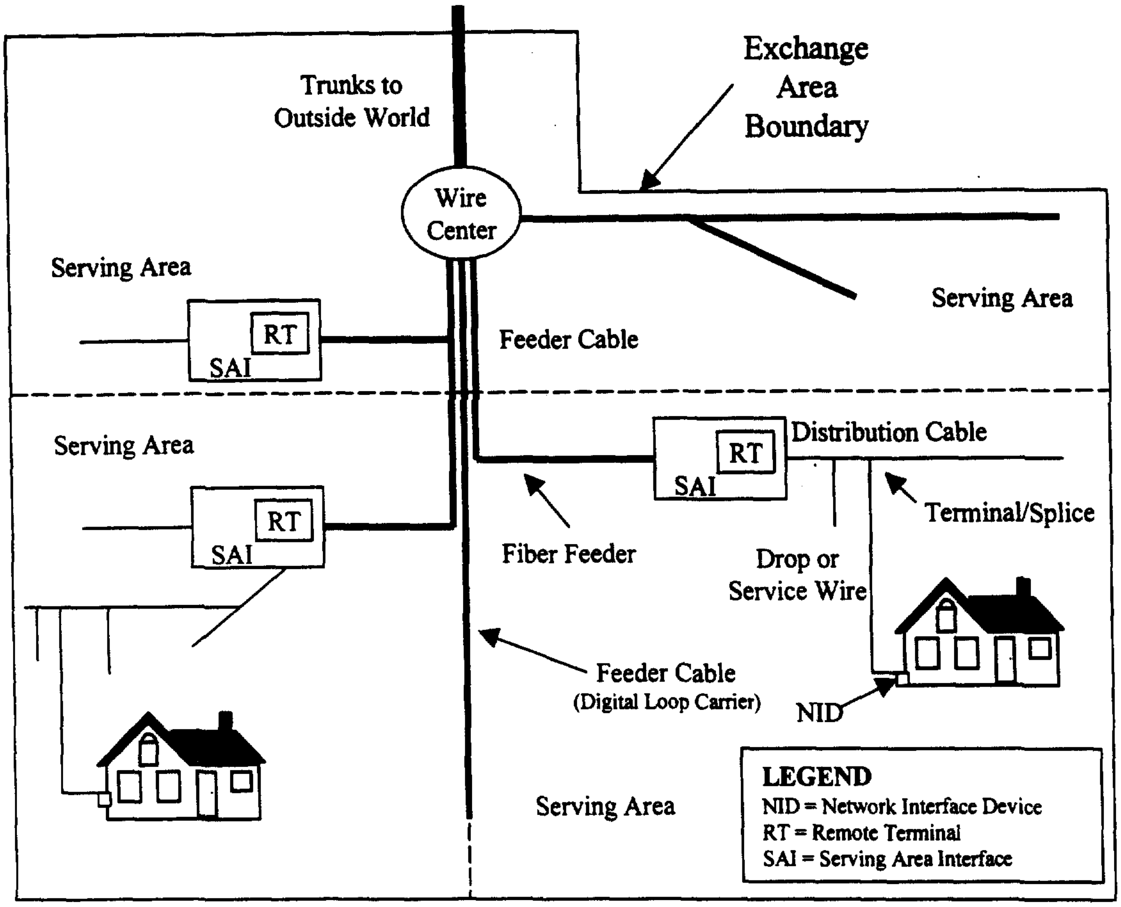
A. GENERAL NETWORK COMPONENTS

This section describes the network configuration and components modeled in HM 4.0. Figures 1, 2 and 3 depict the relationships among the loop, switching, interoffice, and signaling network components.

1. Loop description

Section A provides a general description of the loop. Figure 1 shows those components. Section B describes loop components in detail.

Figure 1 Loop Components



Adapted from Engineering and Operations in the Bell System 2nd Edition, 1983

a) General loop description

The feeder portion of the loop terminates within the central office building, or "wire center." Copper cable feeder facilities terminate on the "vertical side" of the MDF (main distributing frame) in the wire center, and fiber optic feeder cable serving integrated digital loop carrier (IDLC) systems terminates on a fiber distribution frame in the wire center.

Copper feeder cable extends from the wire center to an SAI where it is cross-connected to copper distribution cables. If the feeder is fiber, it extends to a digital loop carrier (DLC) remote terminal (RT), where optical digital signals are demultiplexed and converted to analog signals. Individual circuits from the DLC are cross-connected to copper distribution cables at the adjacent SAI. Copper distribution cable extends from the SAI to the individual customer premises. At the distant end of these distribution cables, the local loop terminates at a network interface device, or NID, at the customer's premises.

Loop cables are supported by "structures." These structures may be underground conduit, poles, or trenches for buried cable and underground conduit. Underground cable is distinguished from buried cable in that underground cable is placed in conduit, while buried cable comes into direct contact with soil.[16]

b) Local Loop Components

(1) Network Interface Device

The NID is the demarcation point between the local carrier's network and the customer's inside wiring. This device terminates the drop wire and is an access point that may be used to isolate trouble between the carrier's network and the customer's premises wiring.

(2) Drop

A copper drop wire extends from the NID at the customer's premises to the block terminal at the distribution cable that runs along the street or the lot line. The drop can be aerial or buried; generally it is aerial if the distribution cable is aerial, and buried if the distribution cable is buried or underground.

(3) Block Terminal

The "block terminal" is the interface between the drop and the distribution cable. When aerial distribution cable is used, the block terminal is attached to a pole in the subscriber's backyard or at the edge of a road. A pedestal contains the block terminal when distribution cable is buried.

(4) Distribution Cable

Distribution cable runs between the block terminals and the SAI. In the Model, distribution cable connects the feeder cable with all customer premises within a Census Block Group (CBG). The model assumes that each CBG contains at least one SAI; limits on the capacity of an SAI and/or the distribution design assumed in particular CBGs may lead to multiple SAIs. Distribution structure components may consist of poles, trenches and conduit.[17]

[16] Although the conduit supporting underground cable is always placed in a trench, buried cable may either be placed in a trench or be directly plowed into the earth.

[17] Because underground distribution exists only in the highest density zones where runs are relatively short, and because in such zones it commonly shares structure with feeder, distribution facilities typically do not

(5) Conduit and Feeder Facilities

Feeder facilities constitute the transmission system between the SAI and the wire center. These facilities may consist of either pairs of copper wire or a DLC system that uses optical fiber cables as the transmission medium. In a DLC system, the analog signals for multiple individual lines are converted to a digital format and multiplexed into a composite digital bit stream. The Hatfield Model assumes that there is a standard (but user-adjustable) feeder distance beyond which optical feeder cable will be installed and DLC equipment will be used to serve subscribers.

Feeder structure components include poles, trenches and conduit. Manholes for copper feeder or pullboxes for fiber feeder are also normally installed in conjunction with underground feeder cable. Manhole spacing is a function of population density and the type of feeder cable used. Pullboxes that are installed for underground fiber cable are normally farther apart than manholes used with copper cables, because the lightness and flexibility of fiber cable permits it to be pulled over longer distances than copper cable.

The costs of structure components normally are shared among several utilities, e.g., electric utilities, LECs, IXCs and cable television (CATV) operators. The amount of sharing may differ in different density zones and between feeder and current distribution.

2. Switching and Interoffice Network Description

This section provides a general description of the network components comprising the wire center and interoffice facilities. Figures 2 and 3 illustrate the relationships among the components described below.

include manholes.

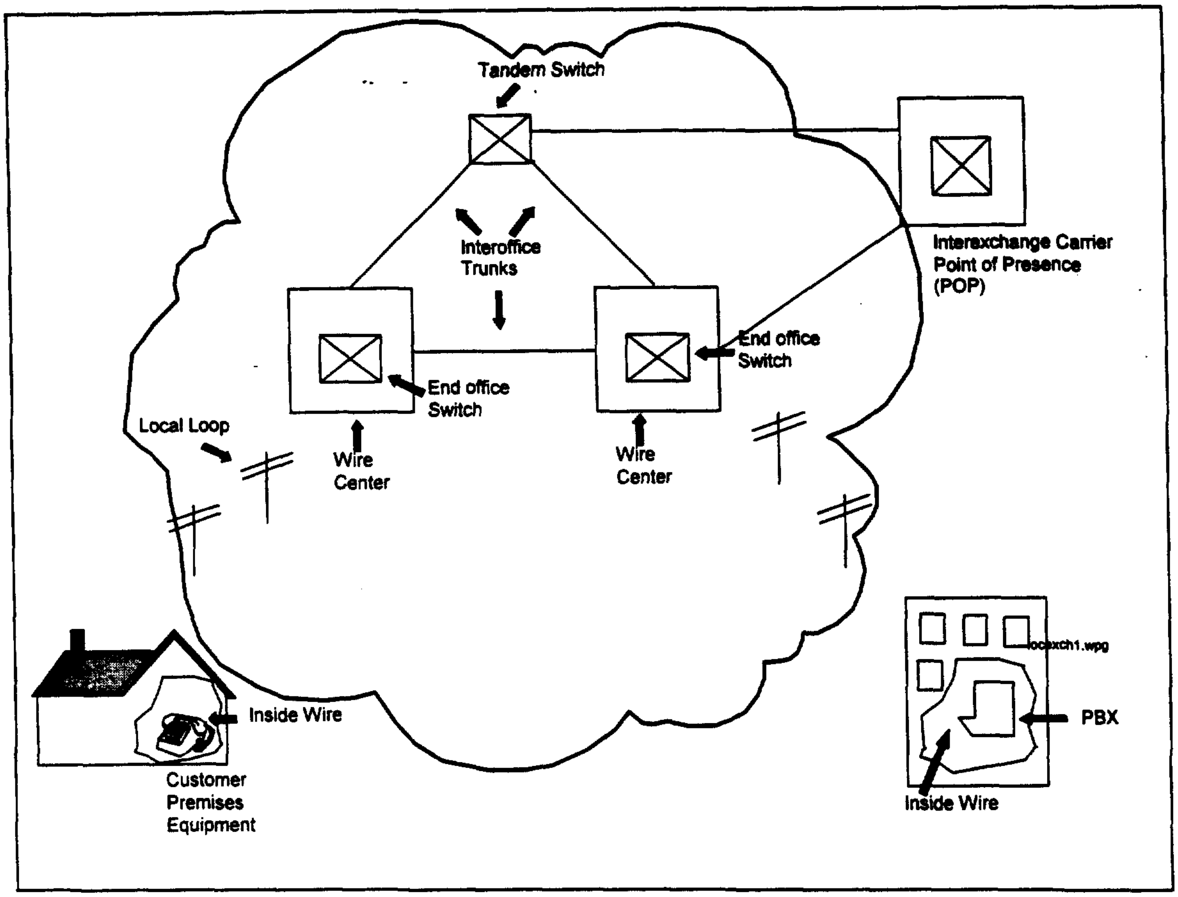


Figure 2 Interoffice Network

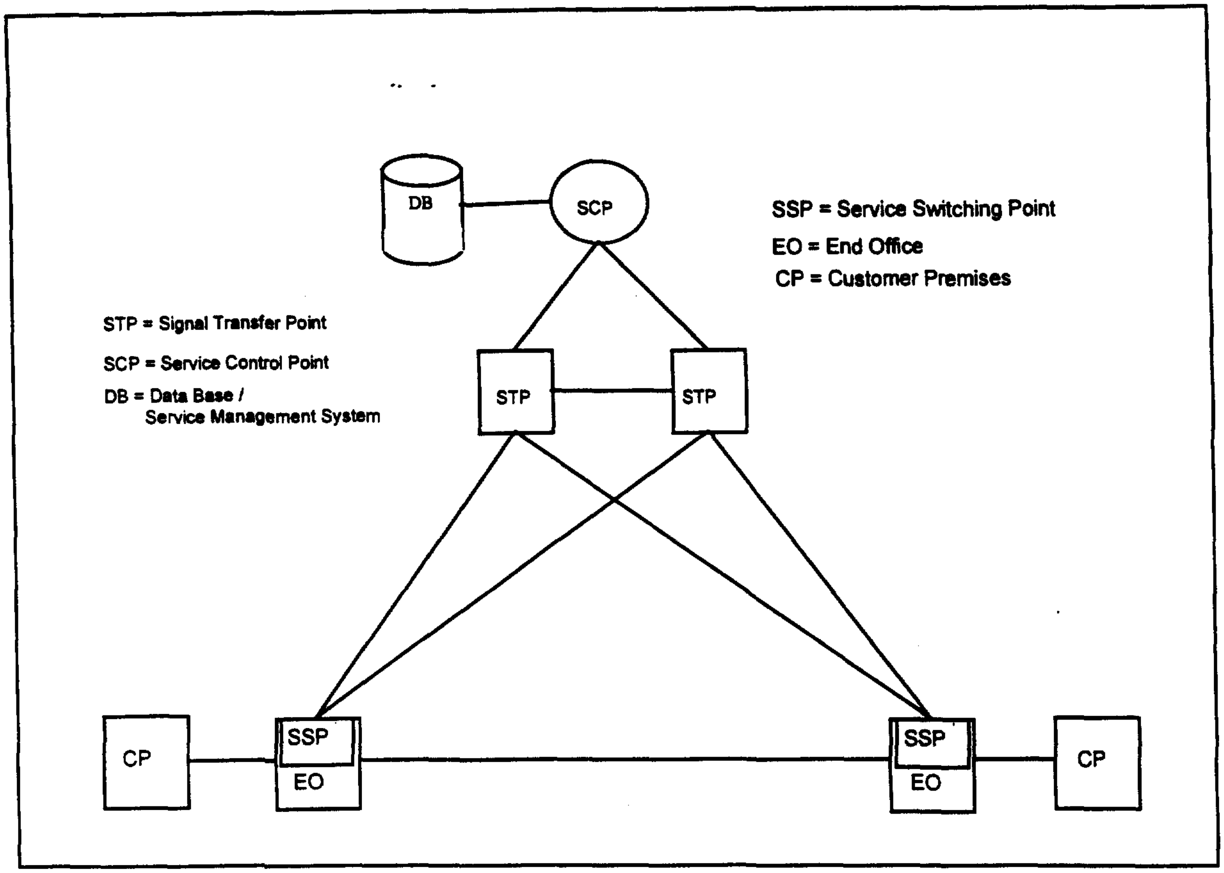


Figure 3 Interoffice signaling network components

a) Wire centers

The wire center is a location from which feeder routes extend towards customer premises and from which interoffice circuits or "trunks" connect with other wire centers. A wire center normally contains at least one end office (EO) switch and may also contain a tandem switch, an STP, an operator tandem, or some combination of these facilities. Wire center physical facilities include a building, power and air conditioning systems, rooms housing different switches, transmission equipment, distributing frames and entrance vaults for interoffice and loop feeder cables.

b) End office switches

The end office switch provides dial tone to the switched access lines it serves. It also provides on-demand connections to other end offices via direct trunks, to tandem switches via common trunks, to IXC POPs via dedicated trunks, and to operator tandems via operator trunks. The model computes the required number of trunks for each route according to input traffic assumptions and the breakdown of business, residential, special and public access lines served by each end office switch.

c) Tandem switches

Tandem switches interconnect end office switches via common trunks, and may also provide connections to IXC POPs via dedicated trunks. Common trunks also provide alternatives to direct routes for traffic between end offices. Tandem switching functions often are performed by switches that also perform end office functions. At a minimum, tandems normally are located in wire centers that also house end office switches.

d) Interoffice Transmission Facilities

Interoffice transmission facilities carry the trunks that connect end offices to each other and to tandem switches. The signaling links in a SS7 signaling network are also normally carried over these interoffice facilities.

Consistent with the evolving practice, interoffice transmission facilities are predominantly optical fiber systems that carry signals in Synchronous Optical Network (SONET) format. Efficient practice also prescribes the use of a fiber optic ring configuration to link switches, except for switches that serve few lines or that are remote from other switches. This provides a redundant path between any two switches, and the potential for substantial cost savings relative to more traditional point-to-point facilities.

e) Signal Transfer Points

STPs route signaling messages between switching and control entities in a Signaling System 7 (SS7) network. Signaling links connect STPs and Service Switching Points (SSPs). STPs are equipped in mated pairs, with at least one pair in each Local Access Transport Area (LATA).

f) Service Switching Points and Signaling Links

SSPs are SS7-compatible end office or tandem switches. They communicate with each other and with Service Control Points (SCPs) through signaling links, which are 56 kbps dedicated circuits connecting SSPs with the mated STP pair serving the LATA.

g) Service Control Points

SCPs are databases residing in an SS7 network that contain various types of information, such as IXC identification or routing instructions for 800 numbers in regional 800 databases, or customer line information in Line Information

Databases (LIDB).

B. OVERVIEW OF MODEL ORGANIZATION

Figure 4 shows the relationships among the various modules contained within HM 4.0. An overview of each component module follows.

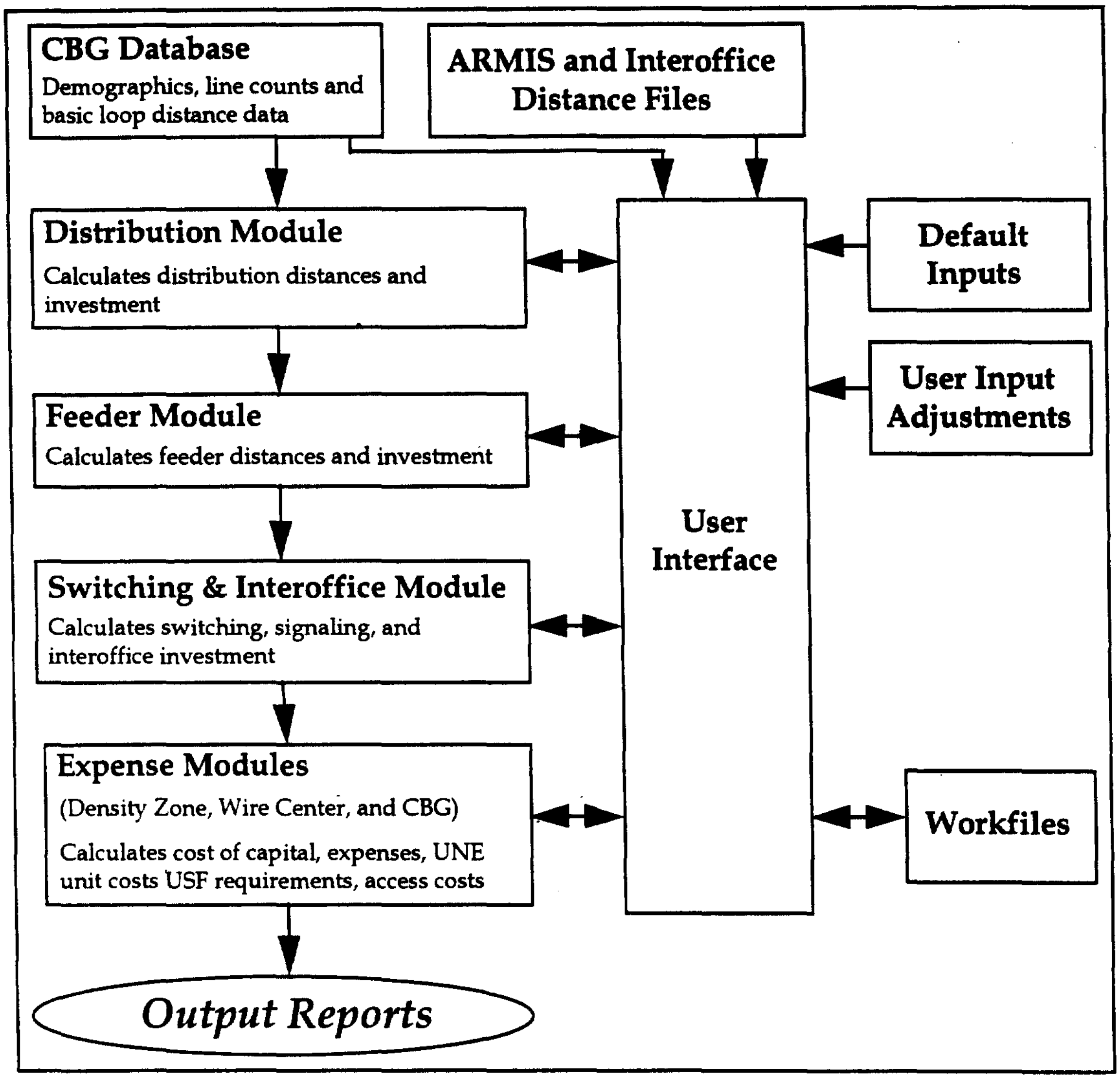


Figure 4 Hatfield Model 4.0 Organization Flow Chart

1. Input Workfiles

Workfiles contain inputs to HM 4.0 and include the following:

- Demographic, geographic and geological characteristics of CBGs, used to locate geographically the number of customers requiring telephone service, the wire center that serves them, and the type of terrain within that CBG.

- Interoffice distances between end offices, tandems, and STPs, used in estimating route miles required for interoffice transmission and signaling facilities - developed from the Bellcore LERG.

- 1995 ARMIS data reported by the LECs, which provide investment, traffic, and expense information; and

- User-adjustable inputs that allow users to set carrier- or locale-specific parameters, and perform various sensitivity analyses. These inputs have preset default values based on the engineering experience and judgment of HAI personnel as well as that of subject matter experts consulting with HAI.

2. Distribution Module

The Distribution Module addresses the portion of the network extending from SAIs to the customers' premises. The module determines the lengths and sizes of distribution cable, the associated structures (poles and trenching), the number of terminals, splices, drops, and NIDs required to provide service to the specified number and type of customers in each CBG, and the number and type of SAIs and DLC terminals required.. The module also calculates certain distances required by the Feeder Module, and, according to those calculations, determines whether to serve a CBG using feeder transmission facilities consisting of copper wire pairs or DLC running over optical fiber cable. This determination is based on several criteria designed to ensure high quality service to all customers. The first of these criteria is a user-adjustable parameter, set to a default value of 9,000 feet, that limits maximum distance of any copper feeder runs.. The second, and perhaps most important of the criteria is to ensure that no total copper loop length, including feeder and distribution, exceeds a user-adjustable parameter whose default value is 18,000 feet. These criteria are described in greater detail in section IV.C.2.

The HM 4.0 Distribution Module serves loops having copper components longer than 18,000 ft with digital loop carrier equipment using copper-based T1 transmission. This technology does not require the use of loading coils or coarse-gauge cable, and it also permits basic rate ISDN and other advanced narrowband services to be provided to all subscriber locations in the model.

Once the module has determined the quantities of all distribution elements, it calculates the investment associated with these elements, using as inputs the user-adjustable unit prices of each element. It provides these investments to the Feeder Module. The numbers and types of elements engineered can be examined in the intermediate outputs of the Distribution Module as recorded in the workfile.

3. Feeder Module

The Feeder Module configures the portion of the network that extends from the wire center to the SAIs. Based on information it receives from the Distribution Module, it determines the size and type of cables required to reach the SAIs located in each CBG, along with supporting structures (poles, trenching, conduit, manholes, and fiber optics pullboxes). The Feeder Module then calculates the investment associated with these elements, using as inputs the unit prices of each such element. It provides these investments to the Expense Modules. The numbers and types of elements required can be examined in the intermediate outputs of the Feeder Module as recorded in the workfile.

4. Switching and Interoffice Module

The Switching and Interoffice Module computes investments for end office switching, tandem switching, signaling, and interoffice transmission facilities. It determines the required line, traffic, and call processing capacity of switches based on line totals by customer type across all CBGs served by the wire center, and based on ARMIS-derived traffic and calling volume inputs. It also determines the required capacity and distances of interoffice transmission facilities, using the traffic data and the interoffice distances that are input to the Module. These investments are then used in the Expense Modules. The numbers and types of elements involved can be examined in the intermediate outputs of the Switching and Interoffice Module as recorded in the workfile.

5. Expense Modules

The Expense Modules calculate the monthly costs for unbundled network elements, universal service and carrier access and network interconnection. These costs include both the capital carrying costs associated with the investments, and the costs of operating the network. Capital carrying costs include depreciation, return on the debt and equity investment required to build the network, and income taxes on equity return. Network-related expenses include maintenance and network operations. Non-network related expenses include customer operations expenses, general support expenses, other taxes and variable overhead expenses.

Information used in developing these monthly costs is obtained from several sources. Network investments by specific plant category are provided by the Distribution, Feeder, and Switching and Interoffice Modules. Information on network operating and maintenance expenses is derived from ARMIS and other sources.

The Expense Modules produce reports showing the key outputs of the model, including the costs of providing universal service, unbundled network elements, interconnection and IXC access. Depending on the user's desired level of aggregation of results, an expense module may be selected the provides outputs by density zone, study area, individual wire center, or CBG.. These outputs are all based on investments calculated at the CBG level.

6. User Interface

The Hatfield Model includes a user interface program that facilitates model operation, including extraction of CBG and other data from the database, executing the Excel workbooks that constitute the model, saving intermediate results, and providing dialog boxes for users to manipulate model inputs.

The user interface program also performs certain simple aggregation and summarization calculations to shorten execution times. Model versions prior to HM 3.0 used Microsoft Excel's Pivot Table feature to summarize various results at the wire center and density zone levels. Although this feature is quite flexible, applying pivot tables to the very large arrays of data required by the model led to very slow execution times. By allowing the interface to make the relatively simple calculations of investment totals by wire center and density zone, as required, model execution time is profoundly reduced.

IV. MODULE DESCRIPTIONS

A. WORKFILES

Work files contain four categories of information, as follows.

1. Demographic and geological parameters